SUMMARY OF ASTRONAUTS' INPUTS CONCERNING AUTOMATION

AN ASSESSMENT OF THE POTENTIAL FOR INCREASED PRODUCTIVITY

FEBRUARY 7, 1990

DAVE WEEKS

NASA/MARSHALL SPACE FLIGHT CENTER

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ASTRONAUT INPUTS ON A&R

BACKGROUND:

ADVANCED DEVELOPMENT PROGRAM STAFF AT HQ RECOGNIZED A NEED TO ENSURE THAT PROGRAM ACTIVITIES STRONGLY CORRELATED WITH SPACE STATION ONBOARD & GROUND SUPPORT USER COMMUNITY NEEDS AS THE SPACE STATION EVOLVES

OBJECTIVE:

CALIBRATE ADVANCED DEVELOPMENT ACTIVITIES FOR THE SPACE STATE BY -

- REVIEW LESSONS LEARNED FROM PREVIOUS MANNED SPACE EXPERIENCES & ANALOGS
- GAIN FURTHER INSIGHT FROM SPACE STATION USER COMMUNITY ON NEEDS/DESIRES
- STRENGTHEN A&R ADVOCACY WITHIN THE ASTRONAUT OFFICE

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ASTRONAUT INPUTS ON A&R

APPROACH:

PERFORM STUDY WHICH EMPHASIZED INCREASED PRODUCTIVITY BY FOCUSING ON -

- LESSONS LEARNED FROM RELATED EXPERIENCES
  - SKYLAB
  - SPACELAB
  - OTHER STS
  - SOVIET SPACE STATION
  - U.S. NUCLEAR SUBMARINE PROGRAM
  - ANTARCTIC RESEARCH STATIONS
- CREW TIME REQUIREMENTS
- FLIGHT CREW & GROUND SUPPORT PERCEPTIONS
  - INTERVIEWED 23 CURRENT/FORMER ASTRONAUTS & PAYLOAD SPECIALISTS
  - INTERVIEWED 22 GROUND SUPPORT PERSONNEL
  - SURVEYED 32 OF ASTRONAUT/PAYLOAD SPECIALIST COMMUNITY

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ASTRONAUT INPUTS ON A&R

ASTRONAUTS/PAYLOAD SPECIALISTS INTERVIEWED

Astronauts/Payload Specialists	Missions Flown
John-David Bartoe	STS 51-F (Spacelab 2)
Gerald P. Carr	Skylab 4
N. Jan Davis	assigned to STS 47 (Spacelab J)
Bonnie Dunbar	STS 61-A, STS 32
Owen K. Garriott	Skylab 3, STS 9 (Spacelab 1)
Edward G. Gibson	Skylab 4
Greg Harbaugh	assigned to STS 39
Henry w. Hartsfield	STS 4, STS 41-D, STS 61-A
David C. Hilmers	STS 51-J, STS 26
Jeffrey A. Hoffman	STS 51-D
Joseph P. Kerwin	Skylab 2
Byron K. Lichtenberg	STS 9 (Spacelab 1)
John M. Lounge	STS 51-I, STS 26
Jack R. Lousma	Skylab 3, STS 3
Story F. Musgrave	STS 6, STS 51-F (Spacelab 2), STS 33
Claude Nicollier	assigned to STS 46
Robert F. Overmeyer	STS 5, STS 51-B (Spacelab 3)
Robert A. Parker	STS 9 (Spacelab 1)
William R. Pogue	Skylab 4
Jerry L. Ross	STS 61-B, STS 27
Rhea m. Seddon	STS 51-D
Robert Springer	STS 29
John W. Young	Gemini III, Gemini IX, Apollo 10, Apollo 16, STS 1, STS 9 (Spacelab 1)

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ASTRONAUT INPUTS ON A&R

RESULTS

A final report will be out this month entitled:

SPACE STATION FREEDOM AUTOMATION AND ROBOTICS:

AN ASSESSMENT OF THE POTENTIAL FOR INCREASING PRODUCTIVITY

HIGHLIGHTS OF THE ASTRONAUT/PAYLOAD SPECIALIST SURVEY BY QUESTIONNAIRE:

Philosophically, 81% favor using advanced automation to increase Space Station productivity

Safetywise, 93% rated FDIR and 84 % rated Exception Reporting/Filtering having potential to contribute some increase to significant improvements

The questionnaire evoked 611 responses regarding 26 specific A&R applications
- **76% indicated having potential for at least some increase in productivity**
- **7% seen with potential for some productivity decrease or significant problems**
- **17% viewed having negligible impact on productivity**

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ASTRONAUT INPUTS ON A&R

ASTRONAUT COMMUNITY INPUTS REGARDING ADVANCED AUTOMATION

- SIMPLE, STANDARDIZED HUMAN INTERFACE (IDIOT-PROOF)
- PROVIDE FLEXIBLE OPERATIONS CAPABILITY
- USER (VERSUS TECHNOLOGY/DEVELOPER) ORIENTED
- DEVELOP & IMPLEMENT THE EASIER APPLICATIONS FIRST
- HELP THE USER TO DO THE JOB EASIER INSTEAD OF MORE DIFFICULT
- INCLUDE "WHAT-IF?" CAPABILITY
- BACKUP MODE OF OPERATION
- SYSTEM MUST BE ABLE TO EXPLAIN CONCLUSIONS/ACTIONS
- AUTOMATE:

  TEDIOUS, REPETITIVE TASKS
  TIME-DEPENDENT TASKS
  CALIBRATION & ALIGNMENT TASKS
  ROBOTIC SET-UP FOR EVA (FOOT RESTRAINTS)

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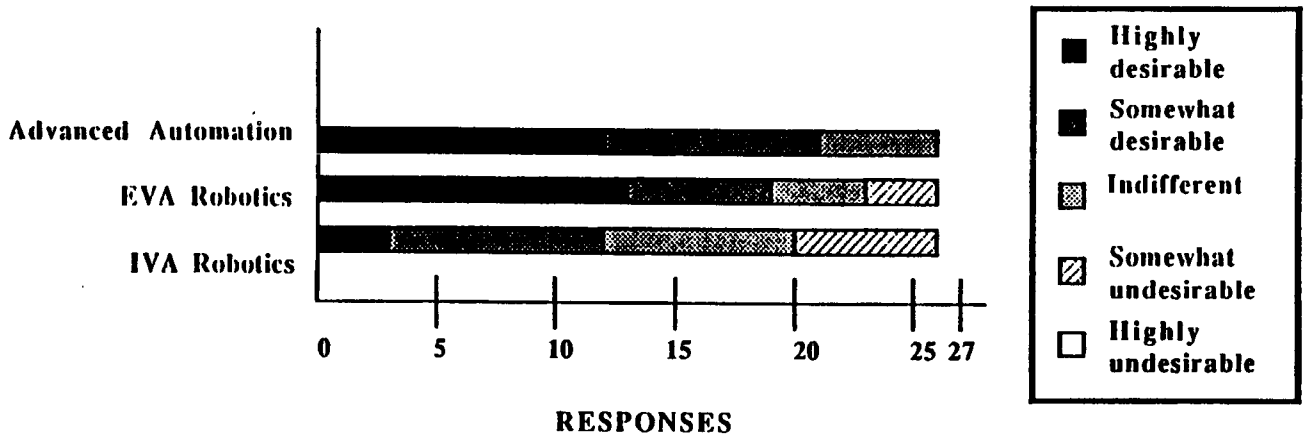
ASTRONAUT INPUTS ON A&R



ASTRONAUT PHILOSOPHICAL VIEWS REGARDING A&R

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ASTRONAUT INPUTS ON A&R

ASTRONAUT SUPPORTED AUTOMATION APPLICATIONS FOR IMPROVING PRODUCTIVITY

OF 32 CURRENT/FORMER ASTRONAUTS & PAYLOAD SPECIALISTS SURVEYED:

- AUTOMATED RECORD KEEPING & DOCUMENTATION (100%)
- AUTOMATED INVENTORY MANAGEMENT (96%)
- AUTOMATED FDIR (93%)
- IMPROVED HUMAN-COMPUTER INTERFACES (92%)
- ROBOTIC CONSTRUCTION (92%)
- ROBOTIC INSPECTION (88%)
- EXCEPTION REPORTING/ALARM FILTERING (88%)
- EXTERNAL CAMERA/LIGHT POINTING (87%)
- ROBOTIC EXTERNAL REPAIRS (85%)
- AUTOMATED TRENDS ANALYSES (INCIPIENT FAILURE DETECTION) (85%)
- CHECKLIST AUTOMATION (85%)

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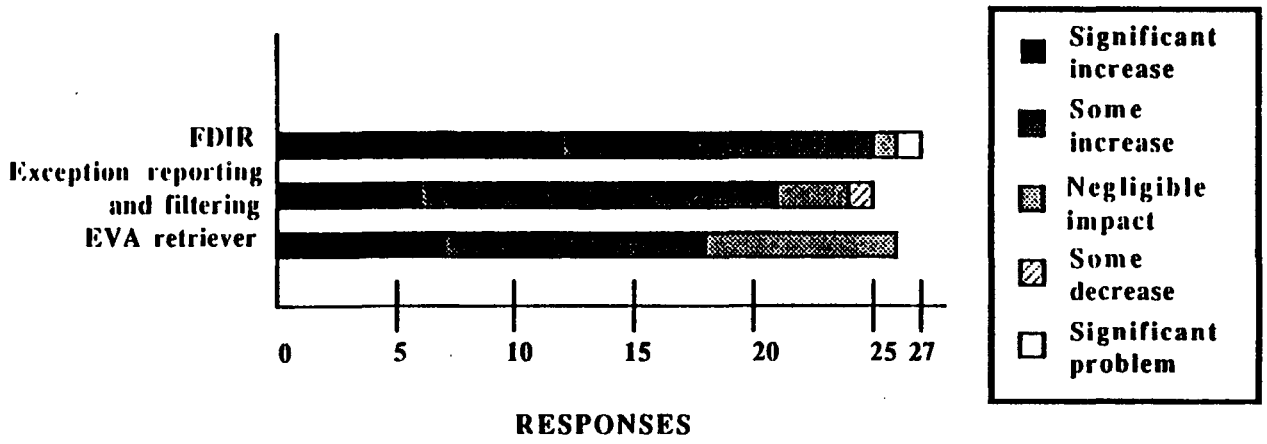

ASTRONAUT RATINGS OF SAFETY IMPACTS OF A&R APPLICATIONS

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ASTRONAUT INPUTS ON A&R

ASTRONAUT SUPPORTED AUTOMATION APPLICATIONS (CONTINUED)

- SYSTEMS MONITORING & CONTROL (82%)
- EVA RETRIEVER ROBOTICS (81%)
- PAYLOAD-SPECIFIC AUTOMATION (79%)
- ON-BOARD TRAINING SYSTEMS (72%)
- PAYLOAD AUTOMATED DATA ANALYSIS (71%)
- PRINCIPAL INVESTIGATOR IN A BOX TYPE SYSTEMS (65%)
- INTERNAL CAMERA/LIGHTING POINTING (58%)
- SPEECH RECOGNITION (56%)
- SPEECH SYNTHESIS (54%)
- ON-BOARD SCHEDULING/RESCHEDULING CAPABILITY (52%)
- IVA RACK ROBOT (50%)
- IVA HOUSEKEEPING ROBOTICS (46%)

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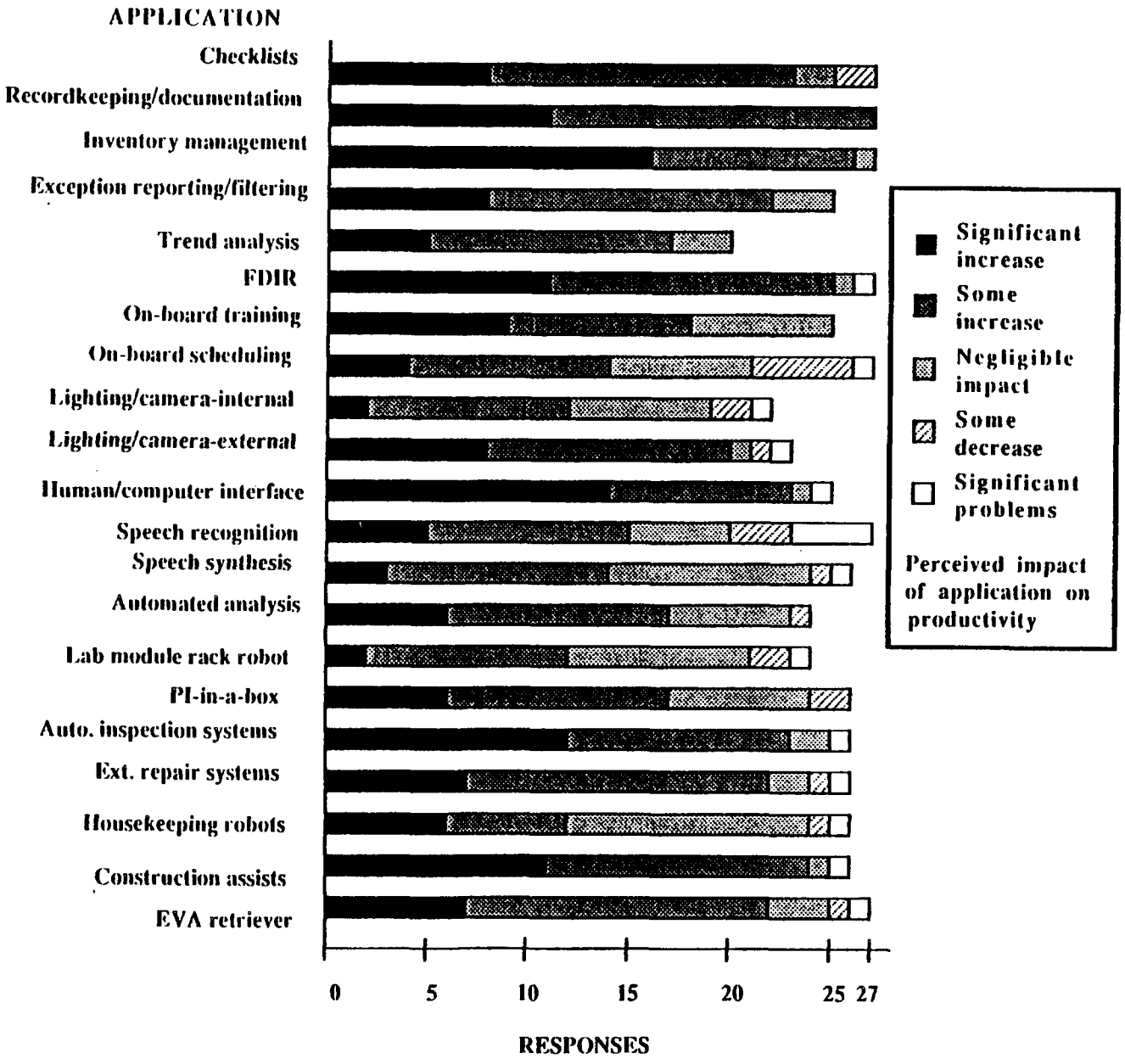

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ASTRONAUT ESTIMATES OF PRODUCTIVITY IMPACT OF A&R APPLICATIONS

ASTRONAUT INPUTS ON A&R

CONCLUSIONS

- STRONG A&R SUPPORT FROM THE ASTRONAUT COMMUNITY FOR APPROPRIATE APPLICATIONS
  - SKYLAB VETERANS MORE SUPPORTIVE OF A&R THAN STS VETERANS
  - STRONGLY SUPPORTED APPLICATIONS INCLUDE
    - INVENTORY MANAGEMENT
    - IMPROVED HUMAN-COMPUTER INTERFACES
    - INSPECTION WITH EVA TELEROBOTICS

- AREAS OF GREATEST POTENTIAL FOR PRODUCTIVITY IMPACT ON SPACE STATION INCLUDE:
  - PAYLOAD OPERATIONS
  - INVENTORY MANAGEMENT
  - SYSTEM MONITORING & CONTROL (INCLUDING FDIR WITH DIAGNOSIS & INTELLIGENT RECOVERY)

- PERSONAL PRODUCTIVITY FALLS OFF SHARPLY AT 8 CONT. HOURS; SPACELAB PRODUCTIVE TIME 70%

- ADDITIONAL PRODUCTIVITY IMPROVEMENT POTENTIAL EXISTS FOR GROUND-BASED SUPPORT:
  - SPACE STATION CONTROL CENTER FUNCTIONS
  - OPERATIONS PLANNING AND INTEGRATION ACTIVITIES
  - TRAINING
  - SOFTWARE MAINTENANCE

- EVA ROBOTICS ALSO HAS GREAT POTENTIAL:
  - MOST COST EFFECTIVE (& SIMPLEST) TO DECREASE ASTRONAUT EVA TIME & INCREASE PRODUCTIVITY - TRANSFER CONTROL OF ROBOTIC ELEMENTS TO GROUND FOR SELECTED ASSY/MAINT/INSPECTION TASKS

- BETTER DEFINITION OF SSF ACTIVITIES/CREW TASKS NEEDED TO PROVIDE FIRM QUANT. EST. OF BENEFITS

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ASTRONAUT INPUTS ON A&R

RECOMMENDATIONS

- DEVELOPMENT OF ADVANCED AUTOMATION & ROBOTICS BE ACTIVELY PURSUED; EMPHASIZED AREAS INCLUDE KBS FOR FLIGHT/GROUND SPT SYSTEMS, HUMAN-SYSTEM INTERFACES, & EVA TELEROBOTICS

- FOCUS ON NEAR-TERM TECHNICAL FEASIBILITY, HIGH POTENTIAL FOR SAVING CREW TIME & REDUCING GROUND SUPPORT STAFFING, AND ACCEPTANCE/SUPPORT BY USERS. INCREASE EMPHASIS ON INVENTORY MANAGEMENT

- ENSURE ADEQUATE PROVISIONS MADE IN SYSTEM DESIGN TO ACCOMMODATE FUTURE INTRODUCTION OF A&R TECHNOLOGY

- DEVELOP ADDITIONAL DATA FOR MORE PRECISE QUANTITATIVE ESTIMATES OF IMPACT OF SPECIFIC SYSTEMS ON PRODUCTIVITY & LIFE-CYCLE COST; INCLUDE COLLECTION OF WORKLOAD & ACTIVITY DURATION DATA FROM SSF ONCE PERMANENTLY MANNED

- PERFORM SYSTEMS ENGINEERING STUDY APPROACH TO TRADE ISSUES INVOLVING ALLOCATION OF FUNCTIONS TO A PERSON, MACHINE, OR COMBINATION THEREOF; TOP DOWN APPROACH SHOULD CONSIDER CREW ACTIVITIES IN TWO CATEGORIES:

  - OPERATIONS - ROUTINE DAILY EVENTS MIGHT BE REDUCED FROM 3 TO 2 HOURS/CREW MEMBER
  - MISSION ACTIVITIES - INVOLVING CREW EXPERIMENTS & NEW CREW JOBS WHICH HAS GREATER POTENTIAL FOR PRODUCTIVITY GAINS.

  THEN, FACTOR IN RELIABILITY, SAFETY, ETC., TO INDICATE HIGH PAYOFF APPLICATIONS

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